

STATE OF ILLINOIS

ILLINOIS COMMERCE COMMISSION

)	
COMMONWEALTH EDISON COMPANY)	
)	
Application for a Certificate of Public)	
Convenience and Necessity, pursuant to)	
Section 8-406.1 of the Illinois Public Utilities)	Docket No. 13-0657
Act, and an Order pursuant to Section 8-503)	
of Illinois Public Utilities Act, to Construct,)	
Operate and Maintain a new 345 kilovolt)	
transmission line in Ogle, DeKalb, Kane and)	
DuPage Counties, Illinois.)	
)	
)	

Rebuttal Testimony of Richard D. Tabors

On Behalf Of

Utility Risk Management Corporation

April 2, 2014

I. INTRODUCTION

Q Please state your name and business address.

A My name is Richard D. Tabors. My Business Address is 1 Memorial Drive, Suite 1410, Cambridge, MA 02142.

Q What is your principal occupation?

A I am President of Tabors Caramanis Rudkevich ("TCR") a boutique energy consulting firm formerly known as Across the Charles ("ATC") and a Senior Consultant to Greylock McKinnon Associates.

Q On whose behalf are you offering testimony in this proceeding?

A I am offering this rebuttal testimony on behalf of Intervenor Utility Risk Management Corporation.

Q What is the subject matter of your testimony in this proceeding?

A My testimony pertains to the application of Commonwealth Edison Company ("ComEd" or "Company") for a Certificate of Public Convenience and Necessity ("CPCN") for its Grand Prairie Gateway Transmission Project ("Grand Prairie Gateway Project," "Byron to Wayne Project," or "Project"). My testimony specifically addresses the written testimonies of ComEd witnesses Nauman, Shanker and McGlynn, and Illinois Commerce Commission Staff witnesses Richard Zuraski and Yassir Rashid.

Q Please summarize your conclusions and recommendations.

A My conclusion and recommendation is that the ICC turn down the certificate of public convenience and necessity requested by ComEd for the Byron to Wayne

Project until full analyses have been undertaken that take into consideration the reduced need for ARRs based on the industry trends toward distributed generation and intelligent communications and controls in the distribution system, and the fact that the load levels upon which ARRs are based are shrinking.

Q. Please review your qualifications.

A. I am President of Tabors Caramanis Rudkevich (TCR), a boutique energy consulting firm formerly known as Across the Charles (ATC), and a Senior Consultant to Greylock McKinnon Associates. Prior to founding ATC and TCR from 2004 until 2012 I was Vice President of Charles River Associates (CRA) and for a number of those years was co-head of the energy practice. I co-founded Tabors Caramanis & Associates in 1988 that was sold to CRA in 2004.

From 1970 until 1976 I was a member of the research staff and faculty of Harvard University. From 1976 until 2006 I was at MIT where I was a Senior Research Engineer and Senior Lecturer in the School of Engineering. In addition I was Associate Director of the LEES (Power Systems Engineering) laboratory and Assistant Director of the Technology and Policy program. I am also a visiting professor of electrical engineering at the University of Strathclyde in Glasgow Scotland. At present I am also a Research Affiliate of the MIT Energy Initiative where I am a Director of the Utility of the Future Project.

I am the author or co-author of over 80 academic articles and 5 books that include *Spot Pricing of Electricity* with Fred C. Schweppe, Michael C. Caramanis and

Roger E Bohn that is considered the initial and basic text upon which all electric energy and transmission markets are based.

My resume is included as Attachment A to this filing.

Q. What is the purpose of your testimony?

A. The purpose of my testimony is to provide support for the conclusions that the Project is not necessary to provide adequate, reliable, and efficient service to ComEd's customers or that the Project constitutes the least-cost means of satisfying ComEd customer's service needs, as provided in Section 8-406.1(f) of the Illinois Public Utilities Act. My conclusions are consistent with the general conclusions of the Illinois Commerce Commission witnesses Richard Zuraski and Yassir Rashid, although I believe the bases for their positions on the Project did not go far enough. I conclude that the Project is not required to satisfy the service needs of the public utility's customers because considerations affecting that conclusion were not evaluated. I believe that the analyses undertaken by PJM in the RTEP process have overlooked a key element in their forecast of future needs, namely that a, if not the, major trend in the US power industry today is toward increased distributed generation, distributed storage and distributed communications and control in the distribution system. These changes in the structure of the power industry are impacting the growth in demand (and revenue) as seen by both the distribution and the transmission sectors of the industry. The resulting change in load directly impacts the need for and allocation of ARR's.

II. BACKGROUND

66 **Q. From the perspective of Docket No. 13-0576, what do you see as the critical**
67 **elements of the history of this proposed transmission investment?**

68 A. The Byron to Wayne Project has been under consideration for a number of years or
69 cycles in the planning process within PJM. According to PJM witness Paul McGlynn,
70 the Project was tested as part of the market efficiency screen in 2010 and 2011 but
71 provided insufficient benefits to be included in the RTEP plan for those years. In
72 2012 and 2013 the Project was selected based on the requirement that PJM
73 eliminate transmission constraints that are limiting simultaneous feasibility of Stage
74 1A ARRs.

75 Mr. McGlynn states, "PJM has an obligation under the PJM Operating Agreement ...
76 to reinforce the transmission system to address constraints that limit the
77 simultaneous feasibility of Stage 1A ARRs" with the implication that a negative
78 decision by the ICC will be overridden by the authority of the FERC.¹

79 Mr. Zuraski and Mr. Rashid take issue with Mr. McGlynn and the ComEd
80 witnesses by testifying that, from the perspective of the Illinois Commerce
81 Commission, it is necessary that there be a demonstrable need for the Project to
82 provide adequate, reliable, and efficient service to ComEd's customers and that the
83 Project constitutes the least-cost means of satisfying ComEd customer's service
84 needs. These two witnesses both conclude, for somewhat different reasons, that
85 need, which must be demonstrated for the ratepayers of Illinois, has not been
86 shown.

¹ McGlynn Rebuttal, ComEd Ex. 14.0, page 12 of 14, lines 207-211.

87 **Q. Do you have an opinion as to the legal position of the ICC vs PJM on this issue?**

88 A. No, I am not a lawyer and am explicitly not offering a legal position on this case. My
89 position is that of an analyst and an economist working primarily in regulated energy
90 industries. My testimony is based upon the materials presented in the case.

91 **III. INDUSTRY TRENDS AFFECTING THE NEED FOR THE BYRON TO WAYNE PROJECT**

92 **Q. Have there been developments in the electric market that you believe are critical to**
93 **the decision to build or not build the Byron to Wayne Project that have not been**
94 **adequately considered?**

95 A. Yes, I believe that a series of forces are challenging the development of large scale
96 transmission projects. These forces include pressure from citizenry resisting
97 transmission development and environmental regulations to reduce or eliminate
98 emissions from coal fired power stations that will, if fully implemented, force the
99 closure of many of the PJM region's coal generation units. In addition, business
100 reports for the Chicago area indicate that Exelon is considering closing certain of their
101 nuclear facilities that they have indicated do not earn sufficient revenues in the PJM
102 market to cover their cost of operations plus return on capital. The Byron unit (at
103 one end of the Byron to Wayne Project) is listed as one of the units in danger of
104 closure. These revelations are consistent with industry trends in which it is widely
105 recognized that coal and nuclear power plants in this country have been coming
106 under increasing pressure to remain financially viable stemming principally from the
107 declining ability of such plants to produce and deliver power that is cost competitive.
108 The pressure for closure comes in large part from inexpensive natural gas and the

109 planned and potential development of gas fired combined cycle units that can be
110 located closer to load. These units have relatively minimal siting impacts and their
111 location near load, as is analyzed by the PJM RTEP report, will reduce the need for
112 new high voltage transmission.

113 In my opinion the most important force at play, one that the RTEP analyses
114 that led to the PJM justification of the Byron to Wayne project appears not to have
115 been adequately considered, is the underlying change in the structure of electricity
116 supply and demand that is taking place. The major changes are the cost
117 effectiveness of distributed solar power systems, improvement in the economics of
118 distributed battery systems, and the creative financing of those investments when
119 combined with an evolution in information technology and intelligent demand
120 response will permanently change the structure of the delivery of electric energy.
121 The focus of the industry by necessity is shifting to operation and servicing of the
122 distribution system. This is a total change from an industry that traditionally has
123 been focused primarily on large scale, frequently distant generation with the
124 requisite high voltage transmission to transport the energy to a distribution system
125 and thereby to ratepayers that only consumed.

126 The proactive consumer, or "prosumer," in the distribution system of the
127 utility of the future is expected to produce, control and consume electricity, all with
128 advanced communications and controls. Should there be any question about the
129 new business models surrounding this trend, one need only look at powerful market
130 indicators like the acquisition of Nest by Google for \$3.2 billion. I believe this type of

transaction points toward substantial growth in the energy customer's intelligent, automated use and control of energy.

Q. Where do you believe that the impact of these changes was missed in the RTEP analyses?

A. I believe that the impact was missed in the forecast of load growth that is the underpinning of the calculation procedure for ARR's that in turn serves as the primary justification for the Byron to Wayne Project as stated by Mr. McGlynn and other ComEd witnesses.

Q. What is your specific criticism of the load forecasts used in the PJM RTEP?

A. My criticism is that the load forecasts, along with the handling of renewable technologies and consumer as opposed to aggregator demand response discussed below is based on an assumption of *status quo* in both methodologies and in conclusions of the direction that demand is headed.

Q. What evidence do you have that the trend of the load forecasts may be overstating future growth and therefore the need for the Byron to Wayne Project?

A. PJM and ComEd have, over the period of 2010 to 2014, consistently reduced their forecast of demand in the ComEd load zone. As can be seen in Figure 1, the "forecast fan" is reduced year on year indicating that while there remains positive demand growth, the overall rate of growth is declining.

Figure 1 also shows the actual peak growth for each of the years in that forecast. There are two points of interest. The first is that there is, as expected, considerable variability in the growth rates and second that the most recent value,

that for 2013 is dramatically below the peak load for either 2011 or 2012 and not far greater than that of 2010.

Q. What conclusion do you draw from the information in Figure 1?

A. While the information in Figure 1 is highly aggregated, it points to the overall trend that is being forecast in the industry and that is that load growth as seen by the distribution (LDC) and transmission entities is declining. As discussed further, this decline is visible to industry observers and is expected to continue and probably continue and even accelerate.

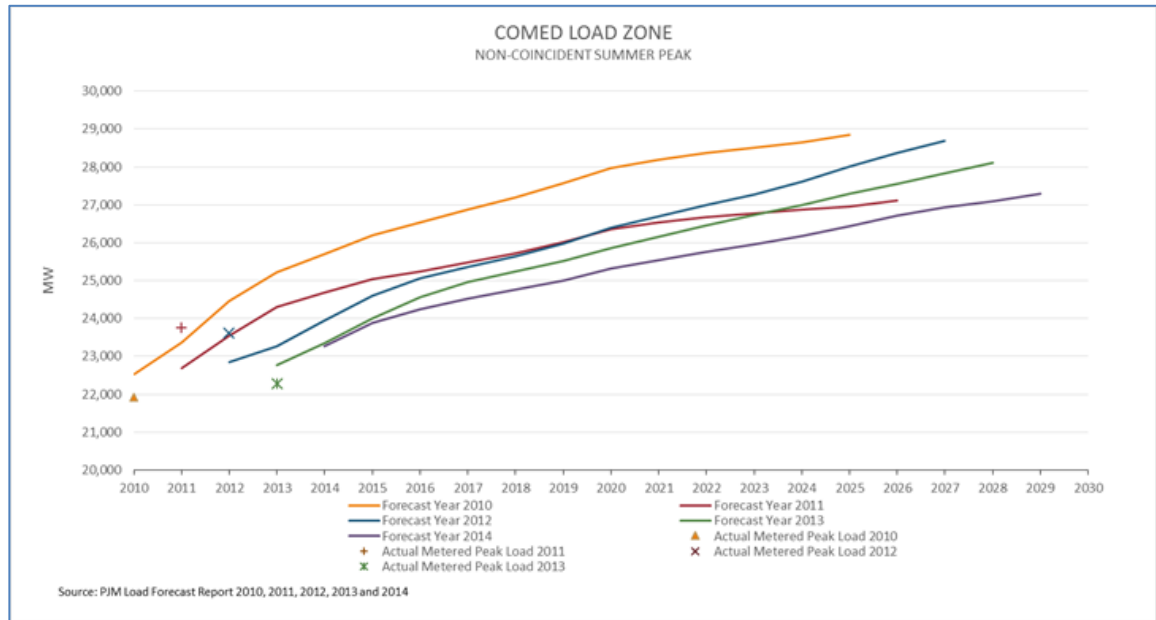


Figure 1: ComEd Forecast and Actual Peak Capacity

Q. Is there other evidence of decline in load that is likely to directly impact the need for ARRs?

A. Yes, as table 1 below indicates, the value used to set the level of ARRs for ComEd, the MW of the minimum peak day, has been uniformly declining since 2009. The

importance of this is that the MW of ARR's that are needed by ComEd load is uniformly decreasing while the ComEd witnesses contend that the demand is increasing.²

Table 1: COMED: Minimum Daily Peak Load

<i>Year</i>	<i>Minimum Daily Peak Load</i>	<i>Relative to 2009 Minimum Peak Load</i>
<i>2009</i>	9,522	100.00%
<i>2010</i>	9,601	100.83%
<i>2011</i>	9,479	99.55%
<i>2012</i>	9,362	98.32%
<i>2013</i>	9,331	97.99%

Q. Do you believe that the PJM RTEP process has adequately addressed the evolution in the utility system that you have identified?

A. No, a review of the assumptions contained in the RTEP 2013 report indicate that the study gives only cursory attention to the changes that are occurring in the distribution segment of the industry. This includes distributed generation, both conventional and renewable, as well as attention to the evolution in independent and behind the meter communications and controls.

Q. Can you explain your contention that the RTEP pays only cursory attention to distributed generation?

A. Yes, while there is discussion of Behind the Meter (BTM) generation and Distributed Generation (DG), in the RTEP analyses the description is of major facilities (those less

² See McGlynn Rebuttal, ComEd Ex. 14.0, p. 9 of 14, starting at line 155.

than 20MW but with an average of just under 10MW).³ The BTM facilities incorporated in the RTEP are important to the PJM system. Though behind the meter, they are not, however, what could be considered to account for all distributed generation as they are at least 3 orders of magnitude larger than the distributed generation being developed for penetration into the small commercial and residential sectors.

The PJM RTEP does recognize the existence of small scale distributed generation but states, correctly, that the “interconnection requests are on the local distribution system removing them from FERC jurisdiction” and thus removing them from the vision and visibility of the RTEP process.⁴

Q. Is this lack of consideration of an important segment of distributed generation of particular concern in terms of renewable technologies?

A. Yes, despite the apparent focus within the RTEP on Renewable Portfolio Standards (RPS) of the eight PJM states, that focus, and the accompanying scenarios, is on large scale systems. This is in contrast to the fact that a significant share of the renewable development, specifically of rooftop solar, is occurring behind the meter. Creative financing by entities such as Solar City have removed the most significant barrier to distributed solar, the front end capital cost.

Q. Beside your own belief based on your industry knowledge and experience, are there other credible authorities who are asserting that this paradigm change of the electric utility structure is inevitable?

³ PJM 2013 RTEP Page 42 and table 3.8.

⁴ *Ibid* p. 42

205 A. Yes, there are multiple, highly credible sources that have asserted that there is a
206 basic paradigm change underway in the industry and that change must be recognized
207 by the incumbent players in the industry. The two most prominent (of many) are the
208 Edison Electric Institute (EEI) that produced a report in 2013 forecasting a death
209 spiral for incumbent utilities and a series of statements by former Secretary of
210 Energy, Dr. Steven Chu.

211 The EEI report gained significant attention because of the role that EEI
212 traditionally plays as the spokesperson for many of the incumbent utilities in the
213 industry. “Disruptive Challenges: Financial Implications and Strategic Responses to a
214 Changing Retail Electric Business” points directly to the death spiral that is
215 characterized by (i) customer departure from the traditional utility as principal
216 energy supplier; (ii) the utility increasing rates to cover decreasing /kWh revenues;
217 (iii) more customers departing the utility services because of lower cost alternatives;
218 and (iv) utilities raising rates.

219 Dr. Chu, after a 4 plus year tenure as Secretary of Energy, was able to observe
220 the trends of the electric sector at close hand and has continued to do so. His
221 statements that utilities are in a shrinking business, and that as solar and batteries
222 get cheaper and cheaper, the utilities will see their best customers install solar.

223 The implication of the scenario painted for EEI by Peter Kind of Energy Infrastructure
224 Advocates, by Secretary Chu and by a myriad of other credible sources is that the
225 industry is moving away from the current paradigm to one in which the growth will
226 be in the distribution sector but that growth will not benefit the current incumbents.

227 **Q: Can you summarize your conclusion from the EEI report, the views of Secretary Chu**
228 **and others, as well as your own view?**

229 A. Most simply stated, it is that unless there is an explicit acknowledgement of the
230 changes that sources like EEI and Secretary Chu are forecasting, large investments
231 such as that represented by the Byron to Wayne Project are likely to become large
232 scale white elephants that have cost a considerable amount in resources and, in the
233 end, do not provide the predicted benefits and turn out not to have been required.

234 **Q. Are there other issues beyond the influx of renewables that are impacting the**
235 **interaction between distributed technologies and the development of large scale**
236 **transmission?**

237 A. Yes, probably the most significant change underway is the influx of communication
238 and control systems at the residential and small commercial level. These systems
239 operating on individual facilities or coordinated into “smart grids” may be owner
240 controlled or coordinated by aggregators. In both instances their actions are
241 intended to reduce consumer costs by modulating demand such that the cost of
242 delivery is lowered. In simple terms this has meant the reduction in peak energy use,
243 the smoothing of daily fluctuations in aggregate load and often (but not always) the
244 reduction in use of transmission and distribution infrastructure.

245 **Q. What is the impact of these changes on the Byron to Wayne Project?**

246 A. The impact on the Byron to Wayne Project is upon what appear to be significant
247 assumptions that underlie the logic for the Project. The Project is based on the
248 assumption that large scale transmission is necessary to protect or hedge the LSE’s

delivery costs for end users. If end users are becoming end prosumers with increasingly sophisticated communications and controls, the need for major transmission investments may be challenged in a manner that the RTEP has not analyzed.

Q. Has the RTEP attempted to identify the impact of the trends that you have identified and created scenarios that allow PJM to evaluate those trends?

A. The RTEP reports of analyses undertaken “to develop a transmission strategy to ensure the deliverability of required aggregate levels of renewable resources to the aggregate of all loads within PJM, not that each state’s goals will be satisfied from resources located solely within each state.”⁵ There are two criticisms of the analyses undertaken.

The first is, as stated. The analysis is based on the assumption that the renewable technologies will be grid interconnected when a significant amount may well not be.

The second is that the 2013 Scenario Study that looked at multiple scenarios related to the state RPS objectives, looked at achieving the objectives 15 years out under 2028 system conditions. PJM in the RTEP used 2028 as the starting point when, in large part, the trends I have described are underway at present. If the experts in whom I believe are correct and observed industry trends continue, the transition will be over long before 2028.

Q. Has the RTEP missed a critical element affecting the need by LSEs for ARR and therefore the need to expand the transmission system to fill the ARR gap?

⁵ PJM 2013 RTEP Page 87.

270 A. Yes, I believe the RTEP is missing the trend in the utility industry that is removing the
271 logic and justification for the need for the quantity of ARRr that PJM is forecasting
272 they will require in the future.

273 PJM has recognized the character of the problem but not the structure in its
274 RTEP discussion of BTM generation when it states that BTM units “are located with
275 load at a single location such that no transmission or distribution facilities owned or
276 operated by any transmission owner or electric distributor are used to deliver energy
277 from the generating unit(s) to load.”⁶

278 The RTEP acknowledges that the impact on PJM (and often the distribution
279 utility) that these distributed generators have are often invisible to the wires
280 companies and do not contribute to their revenues. The key point from the
281 perspective of this discussion is that the distributed generation, renewable
282 generation, and other behind the meter or embedded in the distribution system
283 technologies will reduce the load of the LSE both in absolute terms and on peak. This
284 reduction will reduce the need for PJM to build transmission to fully fund ARR
285 allotments as those allotments will shrink going forward.

286 **Q. Do you believe there is an underlying and faulty assumption in the evaluation of**
287 **the Byron to Wayne Project?**

288 A. Yes. The decision by PJM and ComEd to move forward with the Byron to Wayne
289 Project is based on a vision and RTEP analysis of a status quo that no longer exists.
290 Their status quo has large generating units (even large renewable projects) located at

⁶ PJM RTEP 2013 p. 42.

significant distances from the load; has major forces for inter-regional power transfers and has transmission as the wave of the future. Leaders in the industry now argue that the need for additional high voltage transmission is at best a transitory issue. It is not the need to transfer additional bulk energy that is the challenge for the industry but rather the need to accommodate localized transfer of energy within the distribution and/or sub transmission elements of the system.

The parallel conclusion is that with the changes in the industry the very justification for the Byron to Wayne Project – to assure the funding of ARRs – is in serious question, particularly were one to look carefully to the out years, a step which the current RTEP effort has not, in my opinion, adequately undertaken.

Q. What would be your recommendation to the Commission based on your conclusion of what is not well evaluated in the RTEP?

A. My recommendation to the ICC is to turn down the certificate of public convenience and necessity until full analyses have been undertaken that take into consideration the reduced need for ARRs based on the industry trends toward distributed generation and intelligent communications and controls in the distribution system and the fact that the load levels upon which ARRs are based is shrinking.

Q. Are you challenging the FERC approved PJM tariff?

A. No, I fully recognize and accept the structure of the PJM tariff even though I may question the logic of the elements that allowed such a decision to be made with so little consideration of the economic benefits.

V. CONCLUSIONS AND RECOMMENDATIONS

313 **Q. Please summarize your conclusions and recommendations.**

314 A. I believe that the lack of recognition of and focus on the shifting paradigm of the
315 power industry combined with the history of the decision to move forward and the
316 confused and contradictory valuation of the benefits of the project necessitates a
317 return to the drawing board for the Byron to Wayne Project.

318 Given a forecast by EEI, and Secretary Chu that the prosumer revolution will
319 alter the underpinnings of the industry, it is critical to rigorously challenge the
320 assumptions of need for the Byron to Wayne Project

321 **Q. How does your conclusion directly impact the underlying argument that the Byron**
322 **to Wayne Project is required to balance the economics of the ARR / FTR process?**

323 A. My conclusion is that the trends in the industry are moving in a manner that will
324 reduce the medium and long term demand for ARRs in LDCs like ComEd as
325 distributed resources and communications and control increasingly move supply into
326 the distribution system.

327 Based on the current trends in the industry, not adequately evaluated by the
328 PJM RTEP process, I conclude that the case has not been made that the Byron to
329 Wayne Project is required to meet the PJM FERC approved tariff with regard to
330 maintaining the simultaneous feasibility of ARRs for ComEd. My review of load data
331 indicates that the trend in ComEd load growth shows a steady decline consistent with
332 the development of distributed resources related both to production and to usage.

333 As a result, my conclusion is that the Illinois Commerce Commission should
334 not issue a certificate of public convenience and necessity but should request that

335 PJM undertake additional analysis of the alternatives for satisfying their obligations
336 that reflect both trends within the industry and the criteria the ICC must apply under
337 the Public Utilities Act in order to find that the Project will promote the public
338 convenience and necessity.

339 **Q Does this conclude your rebuttal testimony?**

340 **A** Yes, it does.

RICHARD D. TABORS

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The Maxwell School,
Syracuse University

M.S. Social Sciences,
Syracuse University

B.S. Biology,
Dartmouth College

Richard D. Tabors, Ph.D. is an economist and scientist with 35 years of domestic and international experience in energy planning and pricing, international development, and water and wastewater systems planning. He is currently President and Principal of *Tabors Caramanis Rudkevich* an energy, water and wastewater consulting group in Cambridge, Senior Consultant at Greylock McKinnon of Cambridge and an Affiliate of the MIT Energy Initiative. Prior to forming *Tabors Caramanis Rudkevich* he was president of *Across the Charles*. Dr. Tabors was Vice President of Charles River Associates from 2004 to 2012.

From 1976 until 2006 Dr. Tabors held a variety of position at Massachusetts Institute of Technology culminating in the title of Senior Research Engineer and Senior Lecturer. These positions involved research development and supervision as well as academic teaching and included being Assistant Director of the power systems engineering laboratory (LEES) and associated director of the Technology and Policy master's program. Prior to MIT Dr. Tabors was Assistant Professor of City and Regional Planning and a member of the teaching faculty of the College of Arts & Sciences at Harvard University. At present he is a visiting professor of Electrical Engineering at the University of Strathclyde, Glasgow, Scotland.

Dr. Tabors was a member of the team at MIT that developed the theory of spot pricing (*Spot Pricing of Electricity* Kluwer Academic, 1989) upon which real-time pricing (RTP) and locational marginal pricing (LMP) of electricity and transmissions services are based. While still at MIT Dr. Tabors and coauthors Michael Caramanis & Roger Bohn formed Tabors Caramanis & Associates (1988) that was sold to Charles River Associates in 2004.

Dr. Tabors provides expert assistance and testimony in regulatory and arbitration cases in the energy sector at the Federal, State and Provincial levels in North America and provides technical assistance in electricity markets and market development worldwide. His strength both in academia and in private practice is in the development and management of effective, client and problem focused teams that bring intellectual originality and rigor to the challenges of energy markets.

EXPERIENCE

- 2014–Present *President and Principal* Tabors Caramanis Rudkevich, an Energy and Environmental Consulting Group, Cambridge, MA and Senior Consultant, Greylock McKinnon Associates
- 2013–Present Research Affiliate, MIT and Director, Utility of the Future Project, MIT Energy Initiative.
- 2012–2014 *President and Principal* Across the Charles, Cambridge, MA
- 2004–2012 *Vice President*, Charles River Associates
- Co-director of Energy & Environment practice area.
- 2004–Present *Visiting Professor of Electrical Engineering*, University of Strathclyde, Glasgow, Scotland
- 1986–2006 *Senior Lecturer*, Technology and Policy Program, Massachusetts Institute of Technology (MIT)
- 1988–2004 *Founder and Principal*, Tabors Caramanis & Associates, Inc.
- 1989–1998 *Lecturer*, Department of Electrical Engineering and Computer Science, MIT
- “Introduction to Power Systems Operations and Planning.”
- 1992–1998 *Senior Research Engineer*, Laboratory for Electromagnetic and Electronic Systems, MIT
- 1985–1998 *Assistant Director*, Laboratory for Electromagnetic and Electronic Systems, MIT
- Responsible for laboratory administration and research in power systems economics and planning, research on power systems monitoring and control, principal investigator on research program in performance based monitoring and control.
- 1990–1993 *Principal Research Associate*, MIT
- Co-Faculty “Planning for Water and Sewerage” and “Dealing with the Complete System,” MIT Summer Session.
- 1984–1989 Co-Faculty “Power Systems Planning & Operation: Methodologies for Dealing with an Uncertain Future”, MIT Summer Session.

1978-1988	<i>Lecturer</i> , Department of Urban Studies and Planning, MIT
1973-1988	<i>Principal</i> , Meta Systems <ul style="list-style-type: none"> • utilities group in power systems planning, pricing and systems analysis
1985–1987	<i>Faculty</i> , Course 11.944, Department of Urban Studies and Planning (co-taught as KSG S115 with P. Rogers) “Energy Sector Planning in Developing Countries.”
1971–1976	<i>Research Associate and Member</i> , Center for Population Studies, Harvard University <ul style="list-style-type: none"> • Research on resource and environmental planning in developing nations of South Asia and Africa.
1978–1984	<i>Program Manager</i> , Utility Systems, MIT Energy Laboratory <ul style="list-style-type: none"> • Economic and systems research and development in electric and gas utility systems; including the integration of new generation systems (photovoltaics) into the grid.
1979-1983	<i>Project Manager and Principal Investigator</i> , Electric Generation Expansion Analysis System (EGEAS) Project, under contract to EPRI, MIT Energy Laboratory.
1977-1982	<i>Project Manager and Principal Investigator</i> , Photovoltaics Project, under contract to U. S. Department of Energy, MIT Energy Lab.
1976-1977	<i>Economist</i> , Photovoltaics Project, MIT Energy Laboratory and Lincoln Laboratory.
1976-1977	<i>Energy Economist</i> , New England Energy Management Information Systems (NEEMIS), Energy Laboratory, MIT.
1974-1976	<i>Assistant Professor of City and Regional Planning</i> , Harvard University.
1973-1976	<i>Research Fellow</i> , Environmental Systems Program, Division of Engineering and Applied Physics, Harvard University.
1971–1977	<i>Co-Faculty</i> , with Professor R. Reville, Natural Science 118, & 119, Human Population and Natural Resources, and Population & Environment and in Urban Setting, Harvard University.
1973-1974	<i>Lecturer on City and Regional Planning</i> , Graduate School of Design, Harvard University.
1971	<i>Resident Representative</i> , Harvard University, East Pakistan (Bangladesh) Land, Water and Power System Study, Dacca, East Pakistan.

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- 1970 *Graduate Administrative and Teaching Assistant* to A. K. Campbell, Dean, Maxwell Graduate School of Citizenship and Public Affairs, Syracuse University.
- 1969–1970 *Syracuse University Intern*, Economic Division, USAID Pakistan.
- Informal advisor on Regional Economic Planning to the Urban Development Directorate, Planning Department, Government of East Pakistan (Bangladesh).

CONSULTING EXPERIENCE

- For multiple private power development groups, provides project valuation for generation and transmission. (2000 – Present)
- For the City of New York provided technical and analytic support in the evaluation of the possible closing of the Indian Point Nuclear Generating Station including analysis of the impact of the Fukushima Nuclear accident (2011)
- Provided technical and economic strategy and regulatory assistance to off-shore wind developer (2009 – Present)
- In cooperation with Merrill Energy, provide expert advice on implementation of legislation to recover capital cost of transmission investment in Peru. (2010)
- Direct and provide consulting advice to the Federal Electricity & Water Authority in the United Arab Emirates on corporate reorganization. (2007-2011)
- Provide expert testimony to major US independent power producer in arbitration with steam host. (2007 – Present)
- Direct and provide expert services and consulting advice to Electricite du Liban on revenue recovery through development of AMI systems. (2006 – Present)
- Direct and provide consulting services to Electricite du Liban on restructuring of distribution services. (2006 – Present)
- Provide expert testimony in multiple contract disputes between bankrupt Independent Power Producer and power marketer. (2004 – 2006)
- Provide expert analytic assistance to Private Equity Fund on purchase of generation assets within the United States (2006- 2007).
- Member, Board of Directors, NeuCo Corporation.
- Direct and provide consulting services to Abu Dhabi Water and Electricity Authority on distribution system performance. (2003–2005)

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- Direct and provide expert testimony on the development of the MidWest Independent System Operator. (2002–Present)
 - Direct and provide expert testimony on long-term contract market in California. (2002–Present)
 - Direct and provide expert testimony in purchase, contracting and regulatory approval of Midwestern transmission system. (2002–2003)
 - Direct and provide expert testimony in 9-billion dollar California Electric refund case (2001–Present)
 - Direct and provide expert testimony and consulting to major U.S. market and generator in the redesign of the California electricity market. (2002–Present)
 - Member of the Blue Ribbon Task Force on design of electricity auctions of the California Power Exchange with Alfred Kahn, Peter Cramton and Robert Porter. (2000–2001)
 - Member, Board of Directors of Dynamic Knowledge Corporation, Glasgow, Scotland. (2001–Present)
 - Consultant to more than 20 power development companies for evaluation of locational value of new generation and transmission. (1999–Present)
 - Consultant to and member of Technology Advisory Board, Excelergy Corporation, development of utility billing and system auction software. (1999–Present)
 - Consultant to a Midwest utility for development of transmission congestion pricing structure. (1999–2001)
 - Consultant to transmission asset development team of major U.S. corporation. (1999–2000)
 - Consultant to and member of advisory board of Altra Energy Systems, electronic trading software and platform development company for electronic trading of electricity. (1998–2001)
 - Consultant to major U.S. paper manufacturer for federal regulatory change required to interconnect a new co-generation facility. (1998–2000)
 - Consultant to major Midwest utility in the development of an independent transmission company and the required tariffs. (1998–2002)
 - Consultant with Enron Capital and Trade Resources on U.S. electricity restructuring with specific assignments in California, New York, Massachusetts and New England. Includes testimony in California “Blue Book” en banc hearings and participation in California Competitive Power Market Working Group. (1994–2001)
 - Consultant to the Office of the Attorney General, Commonwealth of Massachusetts for Electric Utility Industry Restructuring. (1995–1998)

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- Consultant with Sithe Energy on electricity pricing and electric industry restructuring. (1995–1998)
 - Consultant with Independent Power Producers of New York (IPPNY) on restructuring of electric sector in New York. (1995–1998)
 - Consultant to the Department of the Attorney General, State of Rhode Island and Providence Plantations for electric utility industry restructuring. (1996–1997)
 - Consultant to the New England Competitive Power Coalition providing support for development of a blueprint for restructuring the New England Power Pool. (1995–1997)
 - Consultant to ABB/Systems Control on transmission pricing and power systems operations. (1994–1997)
 - Consultant to a major western utility for the development of transmission pricing strategies. (1994–1996)
 - Development of real-time pricing strategies and rates for Oglethorpe Power Company, Atlanta, GA. (1995–1996)
 - Consultant on the background to electric industry restructuring to Central Vermont Public Service. (1995)
 - Development of real-time pricing rate response experiments for NYSERDA, EPRI and ESSERCo in ConEd and NYSEG service territories: Response to real-time pricing. (1989–1994)
 - Development of marginal, cost-based, transmission system pricing system for the National Grid Company (NGC) of the United Kingdom. (1991–1993)
 - Development of real-time rate structure and evaluation of customer impacts for Central Maine Power Company. (1990–1991)
 - Development of purchase and transmission strategy for major U.S. independent power producer. (1990)
 - Conservation and load management analysis and testimony for Boston Gas Company. (1987–1988)
 - Development of Electric Power Systems Consulting Group, Meta Systems Inc. (1985–1988)
 - Variable energy cost/spot pricing studies under contract to Integrated Communications Systems of Atlanta. Utilities included Mid-South and Pacific Gas and Electric, Southern California Edison, Central and South West. (1984–1987)

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- Metcalf & Eddy Engineering, analysis of economic benefits of cogeneration/district heating for Columbia Point housing, Boston Redevelopment Authority. (1984–1985)
 - Value of reliability study for Public Service of New Mexico. (1984)
 - With East-West Center, Honolulu, Hawaii, study of electric futures of northeast Asia, Japan, Korea and Taiwan. (1983–1984)
 - Independent variable energy cost spot pricing studies for Georgia Power, Florida Power and Light, Florida Power Corp., Tampa Electric and Gulf Power. (1983–1984)
 - Petroleum pricing study, Philippines for IBRD. (1983–1984)
 - Lignite pricing for electric power generation, Thailand. For IBRD (1982–1983)
 - Independent, review of electric power futures for combustion engineering. (1982)
 - Consultant, Microwave Associates, Inc., on electric load management and control. (1980-1981)
 - Urban energy impact statement for HUD. (1979–1980)
 - Consultant, Urban Systems Research and Engineering. Projects included: Analysis of Boston wastewater management plan for C.E.Q.; definition of 'modal' urban areas for environmental impact analysis using the EPA developed SPACE/SEAS model; Interceptor project to evaluate the impact of EPA interceptor grants program on land use patterns in suburban and rural areas of EPA Regions 2, 4, 6; Rural growth project analyzing regional development in non-metropolitan multi-county areas in the United States. (1971–1977)
 - Urban systems research and engineering analysis of Boston wastewater management plan for C.E.Q. (1977)
 - Bangladesh energy study for Asian Development Bank and UNDP. (1975–1976)
 - Urban systems research and engineering, definition of model urban areas for environmental impact analysis using the EPA developed SPACE/SEAS model. (1975–1976)
 - Land use and environmental quality modeling and case study analysis of land use impacts on water and air quality. Case studies focused on the Mill River basin in the New Haven SMSA. (1974–1975)
 - Member, Technical Advisory Panel for Educational Evaluation in Massachusetts, Office of the Commissioner in Education, Commonwealth of Massachusetts. (1973–1974)
 - Lake Chad polder development study of agricultural development with low-lift irrigation pumping in the area immediately surrounding Lake Chad. (1974)

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- Urban systems research and engineering, interceptor sewer project to evaluate the impact of EPA interceptor grants program on land use patterns in suburban and rural areas of EPA Regions, 2,4,6. (1974)
 - Decision-making and flood plain management in the Connecticut River valley, study for New England River Basin Commission. (1973)

FIELDS OF EXPERTISE

- Energy economics / energy pricing
- Power systems operations and planning
- Asset valuation: Generation, Transmission and Generation
- Water and wastewater management
- Corporate strategic planning and analysis
- Corporate reorganization and management

PROFESSIONAL AFFILIATIONS

- Institute of Electrical and Electronic Engineers
- American Waterworks Association
- International Association of Energy Economists
- Energy Bar Association

PUBLICATIONS

Books, Book Chapters, and Monographs

The Definition of Multifunctional Planning Regions: A Case Study of East Pakistan. A report to the East Pakistan Land, Power and Water Study, Harvard University Center for Population Studies, May 1971.

“Preferences for Municipal Services of Citizens and Political Leaders: Somerville, MA, 1971.” With M.A. Vinovskis. *Population Policymaking in the American States: Issues and Processes*, D.C. Heath and Co., May 1974.

The Syracuse Metropolitan Regions: A Background for Paretian Environmental Analysis. Environmental Systems Program, Harvard University (ESP Monograph), September 1974.

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Interceptor Sewers and Urban Sewers. With Binkley, Collins, Kanter. D.C. Heath and Co., October 1975.

Land Use and the Pipe: Planning for Sewerage. With M. Shapiro and P.P. Rogers. D.C. Heath and Co., November 1976.

"Infrastructure Planning." In ASPO, *Rural and Small Town Planning*, The Old West Regional Commission, 1978.

"Utility Services." In So, Stollman, Beal, and Arnold, eds., *The Practice of Local Government Planning*, International City Management Assoc., December 1979.

"Energy Demand Estimation." With R. deLucia, In Jacoby and deLucia, eds., *Energy Planning in Developing Countries: The Case of Bangladesh*, John Hopkins Press, 1982.

"Traditional/Renewable Energy Sources." With R. DeLucia. In Jacoby and deLucia, eds., *Energy Planning in Developing Countries: The Case of Bangladesh*, Johns Hopkins Press, 1982.

"Utility Spot Pricing to Coordinate Deregulated Utilities, Customers and Generators." With R. Bohn and F. Schweppe. In Plummer, Ferrar and Hughes, eds., *Electric Power Strategic Issues: Deregulation and Diversification*, Johns Hopkins Press, 1982.

Electric Generation Expansion Analysis System, Vols. 1 & 2. With M. Caramanis and F.C. Schweppe. With Stone & Webster Engineering, Vols. 3, 4 & 5, EPRI, Palo Alto, CA, Report No. EL-2561, 1983.

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"Cogeneration: Ownership and Operating Economics." A.H. El-Abiad ed., *Power Systems Analysis and Planning*, McGraw-Hill, 1983.

"The New (Alternative) Electric Generation Technologies: An Evaluation of Their Potential." A.H. El-Abiad ed., *Power Systems Analysis and Planning*, McGraw-Hill, 1983.

“Using Spot Pricing to Coordinate Deregulated Utilities, Customers and Generators.” With R. Bohn, and F. Schweppe. In Plummer, Ferrar and Hughes, eds., *Electric Power Strategic Issues*, Public Utilities Reports Inc., 1983.

“An Approach to Deregulating the Generation of Electricity.” With R. Bohn, B. Golub, and F.C. Schweppe. In Plummer, Ferrar and Hughes, eds., *Electric Power Strategic Issues: Deregulation and Diversification*, Public Utility Reports, 1984.

“Utility Finance and Planning in Japan, Korea and Taiwan.” With M. Castillo-Bonet. In Kim, Smith and Rose, eds., *Electric Futures of Asia and the Pacific*, East West Press Center, Honolulu, 1986.

Electricity in Northeast Asia: The Experiences of Japan, Korea, and Taiwan. Greenwood Press, Westport, CT, 1987.

Spot Pricing of Electricity. With F.C. Schweppe, M.C. Caramanis, and R. Bohn. Kluwer Academic Press, 1988.

Energy Aftermath: How We Can Learn from the Blunders of the Past to Develop our Energy Future. With T.H. Lee and B.C. Ball. Harvard Business School Press, Boston, 1989.

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“Engineering Economic Analysis: Applications to Electric Utility Investment Planning.” In M. Baughman ed., *Engineering Economic Analysis: Overview and Current Applications*, IEEE Tutorial, 1992.

“Unbundling the U.S. Electric Power Industry: A Blueprint for Change.” With Fernando, Kleindorfer, Pickel, and Robinson. Tabors Caramanis & Associates, March, 1995.

Articles and Reviews

“A Preliminary View of Economic Change and Urbanization: Bangladesh 2000.” In Thomas and Lavan, eds., *West Bengal and Bangladesh: Perspectives from 1972*, Asian Studies Center, Michigan State University, South Asia Series No. 21, 1973.

“Urbanization and War: Inertia in Urban Migration in Bangladesh.” Presented to the XXVI Annual Meeting of the Association for Asian Studies, Boston, MA, April 1974.

“Land Values and Public Investment in Urban Fringe Areas: A Case Study of Clay, New York.” With M. Shapiro. Papers and Proceedings of the Northeast Regional Science Association, 1975.

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"A Louisiana Case Study: Towards a Single System of Substrate Regions." With C. S. Binkley. *Growth and Change*, January 1980.

"Homeostatic Utility Control." With F. C. Schweppe, J. L. Kirtley, H. R. Outhred, F. H. Pickel, and A. J. Cox. *IEEE Transactions on Power Apparatus and Systems*, Vol. PAS-99, No. 3, May/June 1980.

"Rate and Penetration Analysis, the Impact of Distributed Photovoltaic Power Systems within the Utility Grid System." With A. Cox, S. Finger, and A. Burns. *IEEE Transactions, IEEE 14th Photovoltaic Specialists Conference*, 1980.

"Economic Integration of New Energy Technologies into the Grid Using Homeostatic Control." Invited paper, IEA Conference on New Energy Conversion Technologies, April 1981.

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"Homeostatic Control: The Utility Customer Marketplace for Electric Power." With F. C. Schweppe and J. L. Kirtley. In *Local Heat and Power Generation: A New Opportunity for British Industry*, Interscience Enterprise, U.K., 1983.

"Deregulating the Electric Utility Industry." With F. C. Schweppe and R. Bohn. *The Energy Journal*, January 1984.

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"Evaluation of Spot Price Based Electricity Rates." With F.C. Schweppe and M. C. Caramanis. *IEEE Transactions on Power Apparatus and Systems*, Vol. PAS-104, no. 7 July 1985.

"Natural Gas Fired Combined Cycle Generators: Dominant Solutions in Capacity Planning." With D. Flagg. *IEEE Transactions on Power Apparatus and Systems*, No. 85 SM 492-4, 1985.

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“Coal to Natural Gas Seasonal Fuel Switching: An Option for Acid Rain Control.” *IEEE Transactions on Power Systems*, Vol. 4, No. 2, May 1989.

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“Benefit Optimization of Centralized and Decentralized Power systems in a Multi-Utility Environment.” With F. Nishimura, M. D. Ilic, and J. R. Lacalle-Melero. *IEEE Transactions on Power Systems*, 1993.

“Transmission System Management and Pricing: New Paradigms and International Comparisons.” Invited Paper, IEEE Power Systems Winter Meeting, February 1993, *IEEE Transactions on Power Systems*, 1993.

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“Zonal Transmission Pricing: A Methodology and Preliminary Results from the WSCC.” *Proceedings of the Conference on Innovative Pricing*, San Diego, March, 1996 and *The Electricity Journal*, November 1996.

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“Zonal Transmission Pricing: Preliminary Results from the WSCC.” With S. Walton. *The Electricity Journal*, November 1996.

“The Regulatory Contract and Restructuring: A Modest Proposal.” With R. S. Hartman. *The Electricity Journal*, December 1996.

“Optimal Operating Arrangements in a Restructured World: Economic Issues.” With R. S. Hartman. *Energy Policy*, Vol. 26, No. 2, February 1998.

“Transmission Markets: Stretching the Rules for Fun and Profit.” With N. Rao. *Electricity Journal*, June 2000.

“Forward Markets for Transmission that Clear at LMP: A Hybrid Proposal.” *Proceedings of the Thirty-Fourth Annual Hawaii International Conference on System Sciences*, January 2001.

“Uniform Pricing or Pay-as-Bid Pricing: A Dilemma for California and Beyond.” With A. E. Kahn, P. C. Cramton, and R. H. Porter. *The Electricity Journal*, July 2001.

“Ex Ante and Ex Post Designs for Electric Market Mitigation: Past and Present Experience and Lessons from California.” With J. B. Cardell. *Proceedings of the Thirty-Sixth Annual Hawaii International Conference on System Sciences*, January 2003.

“The Role of Demand Underscheduling in the California Energy Crisis.” With E.D. Hausman. *Proceedings of the Thirty-Seventh Annual Hawaii International Conference on System Sciences*, January 2004.

"Evaluating the Benefits of Independently-Owned Transmission Companies." *Journal of Structured Project Finance*, winter 2004.

"The use of Multi-Attribute Trade-Off Analysis in Strategic Planning For an Electric Distribution utility: An Analysis of Abu Dhabi Distribution Company" With Rick Hornby, *Proceedings of the Thirty-Fifth Annual Hawaii International Conference on System Sciences*, January 2005.

"Loss Hedging Rights: A Final Piece in the LMP Puzzle." *Proceedings of the Thirty-Fourth Annual Hawaii International Conference on System Sciences*, with Aleksandr Rudkevich , Ezra Hausman , Jan Bagnall and Christopher Kopel, January 2005.

"Price Discrimination in Organized/Centralized Electric Power Markets." With Seabron Adamson, *Proceedings of the Thirty-Ninth Annual Hawaii International Conference on System Sciences*, January 2006.

"Identification and Congestion Analysis of Transmission Corridors of the Eastern Interconnection." With Aleksandr Rudkevich , Kaan Egilmez , Minghai Liu , Prashant Murti , Poonsaeng Visudhiphan , and Thomas J. Overbye, *Proceedings of the Fortieth Annual Hawaii International Conference on System Sciences*, January 2007

"Transmission Tariffs by Use of System and Economic Benefits." With Daniel J. Camac , Raul C. Bastidas , Wilfredo Sifeuntes , and Hyde M. Merrill *Proceedings of the Forty-second Annual Hawaii International Conference on System Sciences*, January 2009.

"Interconnection in the GCC Grid: The Economics of Change." *Proceedings of the Forty-Second Annual Hawaii International Conference on System Sciences*, January 2009

"Development of the Smart Grid: Missing Elements in the Policy Process" With Geoffrey Parker and Michael C. Caramanis *Proceedings of the Forty-Third Annual Hawaii International Conference on System Sciences*, January 2010.

"The Manufacture of Potable Water: Case Analyses of Electric System Alternatives" with Siddarth Nagendraprasad, Ayoob Hussain, Mounir Ayntrazi and Jonathan A. Brant *Proceedings of the Forty- Fifth Annual Hawaii International Conference on System Sciences*, January 2012. (Winner of the Best Paper Award in Power Systems Group)

"Carbitrage: Utility Integration of Electric Vehicles and the Smart Grid" with Edward Kim, Robert Stoddard and Todd Allmendinger. *The Electricity Journal* Vol. 25, Issue 2, March 2012.

"Who's on First? The Coordination of Gas and Power Scheduling" with Scott Englander and Robert Stoddard *The Electricity Journal* Vol. 25, Issue 5, June 2012.

"Learning to Love Congestion: Competitive market problems and their implications for customers' net costs" with Hyde M. Merrill *Public Utility Fortnightly*, July 2012.

"North American Resource Adequacy: "Déjà vu all over again" *Proceedings of the Forty-Sixth Annual Hawaii International Conference on System Sciences*, January 2012

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"U.S. Electrical Energy Demand and the Potential for Photovoltaics." With M. Pope and R. Matlin. Technical Note, Lincoln Laboratory, MIT, November 1976 (TN 76-2).

"The Cost of a Cold Winter." With S. Raskin. *The NEEMIS Newsletter*, Energy Laboratory, MIT, No. 6, Vol. I, January 1977.

"Impacts of Dispersed Solar Space and Hot Water Heating on New England Electric Service." With S. Law and A. Burns. MIT Energy Laboratory, June 1978.

"A Uniform Economic Valuation Methodology for Solar Photovoltaic Applications Competing in a Utility Environment." With P. R. Carpenter. MIT Energy Laboratory Report No. MIT-EL 78-010, June 1978.

"SERI Venture Analysis." With S. Finger MIT Energy Laboratory Technical Report No. MIT-EL 78-032, July 1978.

"Methodology and Definition of Solar Photovoltaic Planning Regions." With P. R. Carpenter. MIT Energy Laboratory Report No. MIT-EL 78-034, July 1978.

"The Economics of Water Lifting for Small-Scale Irrigation in the Third World: Tradition and Photovoltaic Technologies." MIT Energy Laboratory Technical Report No. MIT-EL 79-011, May 1979.

"Homeostatic Control: Economic Integration of Solar Technologies into Electric Power Operations and Planning." MIT Energy Laboratory Report, No. MIT-EL-81-028, July 1981.

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"Utility Spot Pricing Study: Wisconsin." With M.C. Caramanis and R. Stevenson. MIT Energy Laboratory Technical Report No. MIT-EL 82-025, June 1982.

"Market and Economic Analysis of Residential Photovoltaic Systems: Final Report." MIT Energy Laboratory Technical Report No. MIT-EL 82-024, June 1982.

"Industrial Interfuel Substitution Phase I Report: Model Development and Case Study." With G. Russo. MIT Energy Laboratory Technical Report No. MIT-EL 82-035, June 1982.

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“Utility Spot Pricing: California II.” With F. C. Schweppe and M. C. Caramanis. Prepared for California Energy Commission, Final Report, January 1984.

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